A Joint Project to Study the Effects of Ecological Farming Practices on the Quality, Production and Ecological Health of *Cannabis sativa* Grown for Marijuana Products

CONCEPTUAL SCOPE

Conceptual Scope of Research (Vision Goal 1)

Brief Description of Ecological Agriculture (Sub-Goal 1.a.)

Ecological agriculture for food crops has been widely successful where applied, especially when applied on a regional scale. Numerous studies have reported the benefits, which range from reduced pesticide costs and resource use (including water) to increased land productivity and improved produce quality.

Ecological agriculture includes two connected, highly-interrelated areas of strategic interest: building biological diversity into the aerial farm ecology and building fertile, biologically-active, and productive soils. The main return on both interests are decreased economic costs of pest management and increased soil productivity. The strategic concept central to building aerial biodiversity is planting polycultures – untilled patches, blocks and stands of diverse plants including trees, small-trees, shrubs, woody herbs and diverse herbaceous ground plants chosen to support pest-control and soil-building functions. Generally, polycultures should include as many plant families and orders as possible, to represent a wide range of ecological functions (relating to pest control and soil health). Though the main structure of these polycultures involves perennial plants, they can also include biennials and annuals.

Brief Description of Integrated Pest Management (Sub-Goal 1.b.)

Integrated Pest Management (IPM) is a decision-making framework that dovetails perfectly with ecological agriculture. IPM combines strategies to limit pest damage to a level determined by the grower's goals and objectives, while minimizing risk to people, pets, and wildlife. With IPM, the grower uses the minimal intervention necessary to meet production objectives, while favoring smart farm design, prevention and natural control mechanisms. This approach optimizes labor and material costs in the workspace and minimizes chemical impact on the plant. The grower monitors the growing space for pests and responds on a scale and intensity appropriate to the levels of damage and infestation. Low-cost, minimal-risk, and least-damaging solutions take preference.

This approach recognizes that pests will inevitably be present and combines a variety of complementary strategies and tactics to keep pest populations below a harmful threshold. Mimicking natural ecological systems, the grower must integrate these techniques and tactics into a larger, adaptive strategy that begins before catastrophic situations arise, thereby preventing most potential problems.

While IPM is the best approach to responding to infestation crises and crisis-management, its greatest advantage is in avoiding crises through planning, preparation, and prevention. Whether the grower creates a complete, documented IPM plan or briefly outlines an IPM plan, a well-conceived and executed plan can preclude expensive losses to arthropod and pathogen infestation. This report briefly describes the IPM planning and management process.

Brief Description of Target Cultivars (Sub-Goal 1.c.)

Proposed Research (Sub-Goal 1.d.)

The benefits of ecological agriculture to commercial-scale production of *Cannabis sativa* are largely unknown and unstudied. This research project seeks to study "the effects and effectiveness of applying ecological agriculture and agronomy to growing high-quality *C. sativa* for marijuana products, emphasizing product quality and ecological quality of the growing space and farm."

Ecological Agriculture Techniques for Study (Sub-Goal 1.e.)

This research study will organize research questions along these two strategic lines of creating aerial polycultures and building soil fertility and biology, noting the significant inter-linkages as appropriate.

Ecological Agriculture Configurations (Sub-Goal 1.d.i.)

These polycultures are designed to provide alternative food, shelter and water to pest predators and parasitoids, and to partially filter windborn pests. Expected effects include a larger presence of beneficial arthropods and a decreased level of economic damage from pests.

(a) **Blocks, strips and buffers.** Blocks may surround, adjoin, or intervene in fields or blocks of cannabis. A variation of this pattern includes corridors to naturally-vegetated zones.

(b) **Interplanted no-till crop fields.** These patterns interplant cannabis plants with perennial polycultures under no-till management.

(c) **Interplanted annual polycultures crop fields.** These patterns interplant cannabis plants with annual polycultures, otherwise known as cover crops under annual till management.

Steps that support building soil fertility include planting polycultures, as described above, as well as others that create and enhance conditions (physical, chemical and biological) that support biodiversity, thereby supporting pathogen suppression and nutrient-cycling. Expected benefits would include vigorous plant growth and objective evidence of an active and complete soil food web. Some important approaches are:

(a) **Soil organic matter.** This approach physically adds organic matter into the soil profile, including burying entire logs, sheet-mulching, and tilling in or burying substrates like biochar, compost, and or semi-decomposed woody materials. These structures can also add vertical heterogeneity to a field if they are built in mound form. In addition to improving water retention, these structures provide structural, chemical, biological heterogeneity to the soil profile, which translate into diverse habit for diverse soil organisms.

(b) **Soil inoculation**. Soil inoculation involves treating the soil with compost infusions or extractions, tilling in high-biology compost, or treating the soil surface with compost.

(c) **Soil/buried-wood combinations.** Burying decomposing or charred small logs (6”- 14” diameter) intermixed with an equal volume of soil creates a rich complex zone of soil interfaces with significant myceliation and boosted water-holding capacity.

(d) **Eco-intensive beds.** Eco-intensive combine contained raised beds with the soil/buried wood combination, but also use perennial polycultures to provide ecological functions that support the marijuana plants.

Integrated Pest Management Techniques for Study (Sub-Goal 1.e.ii.)

An IPM program depends upon a combination of techniques that begin with supporting biodiversity and soil fertility and a strict policy for eliminating potential infestation sources. proceed through aa series of direct control actions that include environmental, mechanical, biological and chemical applications that do not risk harm to soil organisms and beneficial arthropods. Expected effects include pre-crisis identification of pest presence and infestation crisis avoidance with no loss of value or production.

(a) **Horticulture policy**. A horticulture IPM policy prevents potential infestation sources by such easy, low-cost measures as maintaining a tidy working environment (trimmings and root balls, miscellaneous biomass, empty containers, water puddles, open trash cans), excluding pets, suiting-up workers and guests, and maintaining a vigorous and sanitary cutting and seedling procurement program.

(b) **Monitoring.** Monitoring involves periodic observations of an entire crop or representative samples of that crop. The manager or farmer can use a variety of methods ranging from physical scouting to various forms of traps and filters.

(c) **Direct-Control Framework.** Direct controls begin with mechanical removal (when feasible), and proceed through biological controls (purchased) to application of chemicals including diatomaceous earth, non-toxic soaps, vegetable-based horticultural oils, essential oils and mineral dusts.

Geographical Information System Applications to Cannabis Farming for Study (Sub-Goal 1.e.iii.)

A geographical information system (GIS) is a relational database with mapping capabilities, enabling the planner to create a record for every plant, zone, or other feature included in the design. For example, with GIS, the designer will create a record for each plant on the map – with data on precise location, periodic growth and development, feeding preferences – or any other attribute of interest. The ability to compile individual records on thousands of plants – for costing and purchasing, management and cultural treatment, and research and development – will offer obvious benefits.

At this level of detail, the farm planner can model costs and benefits, facilitating financial planning and budgeting. Using standard database queries, the manager can identify hidden problem spots that appear at larger scale. Further, using GIS with a flexible template, a production template can be easily scaled up and extended onto new farm land. For this project, we will use GIS for these tasks:

(a) **Research block data.** Create GIS shapes and records for map all research blocks, including area, shape and sub-partitioning data, environmental and soil data, and management and cultural practices data (planting, watering, feeding, pruning).

(b) **Cannabis plant data.** Create GIS records for each cannabis plant grown on research plots with data regarding planting time, form, growth and development, and management data (individual variations). Spatial location data will be useful for the IPM program.

(c) **Polyculture plant data.** Create GIS records for each plant in the polyculture features.

Areas of Future Study

These study topics link to a number of different research areas that would yield practical information useful to *C. sativa* (for marijuana) farming, ranging from applications of ecological agriculture to container-based environments to researching the effects of cannabis strain variations on the IPM.

Ecological Agriculture adaptations to container-growing.

Wicking Beds. Wicking beds are semi-contained beds combining a contained water reservoir with container-mix or mineral soil optimized for capillary action. An optimal wicking bed will maintain the soil at field capacity, avoiding saturation, run-through, and salt build-up. This approach might be valuable in a large-scale operation concerned with water conservation and nutrient-optimization.

Capillary Mats and Container Media. When container-growing is the best approach, capillary mats and effective wicking container media offer a potentially water-efficient approach to watering. Container media should contain high-quality composts and biochar and can work with a system of periodic, supplementary inoculation.

Effects of Variations in Cannabis Strains on IPM and Soil Fertility

These studies would investigate the response of several different strains to the growing space configurations and their response to an IPM program.

Effects of Fungal polycultures

Mutualistic and saprophytic fungi can contribute to soil ecology in many ways, ranging from forming mycorrhizal relationships and adding glomalin to the soil to increasing water retention and adding a variety of secondary metabolites to the soil.

Effects of Biodiverse composts

Bio-diverse composts can add signficant biodiversity to the soil food web, as well as contributing a host of secondary metabolites and available nutrients.